that the Weather Bureau investigate the question why some kinds of trees are more frequently struck by lightning than others. He suggests that actual experiments with artificial lightning, such as that given by the apparatus constructed by Prof. John Trowbridge, at Harvard University, may be able to show the intrinsic differences in the effect of the discharge through different kinds of wood, and that the physicist, the Weather Bureau, the Division of Forestry, and the Division of Vegetable Pathology might combine in this study. On the other hand, Professor Trowbridge writes us that "the character of the wood, whether oak or pine, weighs but little in comparison with other physical conditions." The following paragraph quoted from Mr. McAdie's letter of February 19, 1898, will suggest lines of study to many voluntary observers:

I have the honor to invite attention to the need of an authoritative answer to the question "Why some trees are more frequently struck by lightning than others?" At first glance the subject may seem to be foreign to the work of the Weather Bureau; but investigation will show that some phases of the question are germane to the work of this Bureau and proper subjects for study.

Primarily it is a matter of saving human life; and in that direction the Weather Bureau has always put forward its best efforts. Many people, particularly farmers and those who work in the fields exposed to thunderstorms, will work until the storm is almost upon them, and then run to the nearest tree for shelter. If the tree is an oak and the charged thunder clouds are moving toward it, with high electrical potential, the person or persons under the tree are in the line of strain, and all unconsciously are contributing to the establishment of a path for the lightning discharge through themselves. Records show how frequently death results, and how dangerous it is to stand under certain trees during thunderstorms. On the other hand, if it had happened to be a beech tree, there is some reason to believe that it will afford safety as well as shelter, though the reason why is not at present known. It is known that the oak is relatively most frequently and the beech least frequently struck. If the relative frequency of the beech is represented by 1, that for the pine is 15, trees collectively about 40, and oaks, 54. Trees struck are not necessarily the highest and most prominent. Oak trees have been struck twice in the same place on successive days. Trees have been struck before rain began and split; and trees have been struck during rain and only scorched. It is plain then that before any statement is made as to the danger of standing under certain kinds of trees during thunderstorms, the more general questions of the effects of lightning upon trees should be gone into. Such a study would be best undertaken by cooperated effort of statistician, physicist, and vegetable pathologist.

The Editor hopes that those familiar with the forests in their respective neighborhoods will contribute a few words as to their own local experience in the matter of the relative frequency of lightning strokes on different kinds of trees. Of course, their statements must be accompanied by a careful estimate of the relative number or frequency of the trees themselves. Thus, if in a forest where oaks and pines are fairly well distributed, the pines are twice as numerous as the oaks, and it has been found by actual count that during any given number of years, 10 oaks and 5 pines have been struck, it will, of course, follow that the relative frequency of the lightning strokes is as 4 to the oak and 1 to the pine.

In this connection the following remarks by Mr. Austin Cary, of East Machias, Me., have just been received. Mr. Cary has had wide experience in the forests of New England, and says:

The only trees I ever noted struck by lightning were large spruce and pine and, sometimes, stubs left after a fire in burnt land. My idea was that the tall, prominent trees attracted the strokes. Pines usually stand high above the surrounding timber. I certainly think such trees are particularly liable to be struck. I have also frequently seen large spruce hit by lightning. Sometimes a narrow cut is made down the bark; sometimes big, long splinters are split out and thrown around. I do not remember ever to have seen a hard-wood tree marked by lightning. The flat crown of these trees and the comparatively even cover which a hard-wood forest presents may explain this. I learn, however, that elms are likely to be struck. This may be because they, as shade trees, stand apart.

TIN ROOFS AS LIGHTNING CONDUCTORS.

Under date of May 28, 1887, the journal of the Weather Bureau station at Little Rock, Ark., which was at that time kept by Mr. W. U. Simons, says:

A thundershower; thunder very heavy, and brilliant, zigzag and ball lightning, at times very near; night cloudy. Rossner Block struck by lightning.

In a recent letter, dated July 13, at Key West, Mr. Simons gives a fuller account of this event, as follows, having especially in view the efficacy of a tin roof as a means of protection against damage by lightning:

Mr. Fred. Rossner had recently erected a large three or four story brick building, with a tin roof, distant from the Weather Bureau office about 300 feet. During a heavy rain and thunderstorm a flash of lightning struck the roof of the Rossner building. I was standing at the office window, and, although for an instant the flash blinded me, I saw it apparently cover the entire roof with a thin blue flame, resembling alcohol burning on a flat surface. Almost immediately it appeared to flow toward the southeast corner of the building and disappeared. I learned afterward that it had passed down the waterspout at that corner of the house, and where it went to earth there was a hole in the ground about the size of an ordinary water bucket, but not a joint of either the tin roof or the waterspout had been melted. My idea of it at the time was that the rain on the roof formed such a complete covering that the electricity diffused itself through that, then followed the waterspout to the ground, using the water as a conductor.

From the preceding description it would seem that in this case the building was saved from injury, not so much by the tin roof and tin water spout as by the layer of rain water that fortunately covered the roof and filled the spout at that time. Had the roof and spout been dry, it might well have happened that every soldered joint had been melted and many a square of tin burned to destruction; under such circumstances, the building itself would have been in great danger.

RAIN GUSHES AND THUNDERSTORMS.

The article in the MONTHLY WEATHER REVIEW for July, 1897, page 303, has called forth several letters during the last year from those interested in the subject from which we quote as follows:

Prof. Milton Updegraff, Director of the Astronomical Observatory of the State University at Columbia, Mo., says:

I remember seeing somewhere the following plausible explanation of the connection between rain gushes and lightning. The large drops of rain, being formed from smaller drops of water, must be charged on their surfaces to a higher electrical potential than the smaller drops of which they are formed, for obvious geometrical reasons. Thus, a sudden and simultaneous condensation in a cloud would produce a higher electrical potential which might cause a flash of lightning which would be seen shortly before the rain drops reach the earth.

Mr. H. D. Gowey, of North Lewisburg, Ohio, remarks:

It is a general expression "that a harder rain, in general, immediately succeeds a flash of lightning or heavy thunder." I have noticed this many times in the last sixty years. If the hard thunder was about overhead then comes the harder rain, but if far distant the harder downpour for a minute or two may not come. There may be electrical attraction or repulsion between the particles of moisture that on a stroke of lightning lets them unite and fall in large drops of rain, but if no lightning so that their electricity may pass off they repel each other and not much rain falls from that cloud. In hot weather, almost invariably, if a heavy cloud arises in the west or in a westerly direction and is not accompanied by thunder then generally very little rain falls from it, but if accompanied by heavy thunder there is a heavy rainfall as long as the thunder lasts, when that ceases the rain also stops. Rain invariably follows thunder [or the thunder (and lightning) follows the rain]. Therefore, to have a "rain gush" the thunder must be overhead (in the zenith) or a little west of it. When a nimbus cloud arises in the west (in hot weather) not much rain may be expected to fall from it unless accompanied by thunder and lightning. Can not electrical attraction and electrical repulsion account for a part, at least, of the phenomena?

Prof. H. A. Hazen, of the United States Weather Bureau at Washington, says:

On Saturday, June 25, 1898, while standing in a sheltered place in this city I had an excellent opportunity for noting thunderstorm phenomena. At 18*h*. 49*m*. there was a brilliant flash nearly overhead, and after an interval of seven or eight seconds there came a dash of rain which lasted about a minute. The rain had almost ceased before the next flash. Again, at 18*h*. 51*m*., there was another strong flash, and rain occurred after three or four seconds. The general rain was quite intermittent, and I noted a similar sequence twice more, but without noting the time. The impression was strong at the time that this was clearly a phenomenon of cause and effect. I have noted the same phenomenon several times before but never so markedly as on Saturday.

On comparing this record with that of Mr. Masterman on page 304, Vol. XXV, we must conclude that lightning precedes rain and follows rain with about equal frequency. Moreover, there are far more numerous cases that will have occurred to every careful observer, where severe lightning flashes have not been closely attended by a rain gush, either before or after, so that the causal connection is not only not clearly made out but is even highly improbable.

It is still too soon to announce any positive conclusion as to the connection between lightning and rainfall. Observations, suggested hypotheses, and experimental testing of the same are still in order.

THE ORIGIN OF ATMOSPHERIC ELECTRICITY.

Almost every suggestion that has ever occurred to any one as to the origin of atmospheric electricity, and the part it plays in meteorology, has been tested over and over again during the past century with only negative results. Some of these are noted in the following paragraphs:

Volta and De Saussure suggested the evaporation of the natural waters on the surface of the globe, all of which are more or less impure, but Pouillet showed that electricity could not come from the evaporation of pure water, but might come from salt water and also from the evaporating surfaces and chemical changes incident to vegetation. De la Rive showed that vegetation was entirely insufficient, and Reiss showed that evaporation of salt water does not, of itself, produce electricity; on the other hand he showed that the friction of drops of water against the sides of a platinum vessel would produce a small amount.

The hypothesis that our electricity comes from the action of the sun in heating the atmosphere as also that it is produced by the friction of warm air against cold air have both been examined, but experiment has never been able to demonstrate the slightest trace of thermo-electricity in gases and vapors.

Schoenbein considered that the oxygen of the air might act electro-chemically upon the molecules of water of which the clouds are composed, but this again has received no experimental confirmation and could hardly account for the electricity that we find in the clearest dry air. E. Becquerel suggests the decomposition of organic matters, but this, also, is not considered sufficient. It is recognized on all sides that the evaporation of terrestrial waters may carry the negative electricity at the surface of the ground upward into the atmosphere, but this does not explain the origin of that electrified state at the surface nor the fact that the atmosphere remains positive while the earth remains negative.

De la Rive considered that the continual chemical action taking place in the interior of the globe explains the origin of terrestrial electricity and that, as beneath the ocean this action is due to infiltration of sea water, therefore, the ocean is charged with positive electricity, but the solid continents with negative. Especially in the equatorial regions would the atmosphere receive from the sea those positively electrified vapors which, after overflowing into the two hemispheres, would descend in the polar regions and produce auroras, lightning, etc. But this fascinating and comprehensive theory seems to be not at all in harmony with the recent careful observations as to the nature of the electrical distribution in latitude and over oceans and continents. It is generally acknowledged that a great amount of electrified vapor and dust is carried up in every volcanic eruption, but although the quantity is enormous yet it is not sufficient to explain the condition of the whole atmosphere, although we may thereby explain some of the variations in its general electrified condition; this volcanic electricity apparently originates in a variety of ways, especially from friction.

The fact that a magnetized body when in motion gives rise by induction to an electric current flowing through a neighboring conductor has led Rowland and S. P. Thompson to calculate the electric effect of motions, such as the wind blowing over the surface of a magnetized globe, or the effect of the rotating magnetic earth upon the ether of space in its neighborhood. But here again the electric effect turns out to be too small.

The discovery by Arrhenius that sunlight, especially the ultraviolet rays, greatly diminish the insulating power of dry air and produce what is called photo-electric dissipation and the phenomena discovered by Hallwachs that a conductor carrying a negative charge gives it up to the surrounding gas when struck by a ray of ultraviolet light have given rise to the idea that in this way the sunlight acting upon one-half of the earth's atmosphere may discharge the electricity therefrom as well as from the earth and ocean beneath the air; but this, again, has not yet been demonstrated by experiment.

Faraday and Sohncke have shown that dry crystals of ice, such as may occur in the coldest dry air, may become positively electrified by friction, as for instance by descending through the air, and Sohncke has formulated a theory explanatory of the electricity of thunderstorms as dependent upon the behavior of cirrus and cumulus clouds. The electricity is generated in the region of the isothermal surface of 32° F., but this ingenious view still waits for its confirmation. Brillouin has advanced an ingenious explanation of the origin of atmospheric electricity, based upon the action of ultraviolet light upon the crystals of ice that constitute cirrus clouds (see MONTHLY WEATHER REVIEW for 1897, p. 440), but some points in his theory remain to be established by further experimentation. P. de Heen suggests that as solar radiation illuminates and heats the earth, so it also has the power to electrify the upper strata of air; that these in fact, as it were, absorb the electric influence and then being electrified act indirectly on the ground below. Maclean and Lenard have studied the electrification of the air by drops of water falling through it. It is found that falling water drops give the air a negative charge, but so also do snow crystals; therefore, the higher strata of air should be negative instead of positive, as actually observed. Marvin observes that a rain of fine drops of mercury in dry air electrifies the drops and presumably the air. Palmieri has shown that the condensation of aqueous vapor in and of itself does not develop electricity. Gay Lussac and Pouillet did the same for all changes of condition from solid to fluid to vapor to gas, and the reverse; no electricity is developed except in the change from fluid to solid, when some solids, such as sulphur, show slight manifestations which are due to the action of the edge of the solidifying liquid on the glass vessel containing it.

The inductive action of the earth on its atmosphere is undoubtedly important, but the action of the sun, distant as it is, may be appreciable. Edlund and Siemens have advocated the solar origin of atmospheric electricity, but their hypotheses have not yet been generally accepted.

The spread of the electro-magnetic telegraph lines and the electric cables over the globe has shown that local electric currents generally flowing in an east-west direction exist everywhere in the earth, thus suggesting that the electrified condition of the atmosphere depends upon them. Clerk Maxwell in his treatise on electricity after recognizing that all other